Half Life

1) Carbon-14 has a half-life of 5730 years. How long will it take for the quantity of carbon-14 in a sample to drop to one-eighth of the initial quantity? [3 half-lives; 1.719 x 10^4 years]

$\frac{1}{2}\left(\frac{1}{2}\right)\left(\frac{1}{2}\right) = \frac{1}{8}$

3 half lives!

5730 years (3)

= 17190 years

2) Astatine-218 has a half-life of only 1.6 s. About how long will it take for 99% of a sample of astatine-218 to decay? [About 11 s]

Look at chart: about 7 half-lives or $\left(\frac{1}{2}\right)^7 \approx 99\%$

1.6 s (7) = 11.2 s

3) Radium-226 has a half-life of 1600 years. What percentage of a sample of radium-226 will remain after 8000 years? [3.125 %]

$n = \frac{8000}{1600} = 5$ $\quad N = N_0\left(\frac{1}{2}\right)^n$

$\frac{N}{N_0} = ?$ Percentage left $\quad \frac{N}{N_0} = \left(\frac{1}{2}\right)^n$

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^5$

$\frac{N}{N_0} = \frac{1}{32} = 0.03125$

$\approx$ 3.125 %

4) Radon-222 has a half-life of 3.82 days. What percent of a sample of this isotope will remain after 2 weeks? [7.9%]

$n = \frac{14 \text{ days}}{3.82 \text{ days}}$ $\quad N = N_0\left(\frac{1}{2}\right)^n$

$\frac{N}{N_0} = ?$ $\quad \frac{N}{N_0} = \left(\frac{1}{2}\right)^n$

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{\frac{14}{3.82}}$

$\frac{N}{N_0} = 0.078840379 66$

$\frac{N}{N_0} \approx 7.9\%$

5) Strontium-90 has a half-life of 29.1 years. What percent of a sample of this isotope will be left after 100 years? [9.24 %]

$n = \frac{100}{29.1}$

$\frac{N}{N_0} = ?$

$N = N_0\left(\frac{1}{2}\right)^n$

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{\frac{100}{29.1}}$

$\frac{N}{N_0} = 0.09237036526$

$\frac{N}{N_0} \approx 9.24\%$

6) Tritium(${}^3_1H$) has a half-life of 12.3 years. How much of a 100-mg sample of tritium will be left after 5.0 years? [75%]

$N = ?$

$N_0 = 100\text{mg}$

$n = \frac{5.0}{12.3}$

$N = N_0\left(\frac{1}{2}\right)^n$

$N = 100\text{mg}\left(\frac{1}{2}\right)^{\frac{5.0}{12.3}}$

$N = 75.444934\,02\text{mg}$

$N = 75\text{mg}$

or about 75%

7) What fraction of a radioactive material remains after four half-lives? [1/16]

$\frac{N}{N_0} = ?$

$n = 4$

$N = N_0\left(\frac{1}{2}\right)^n$

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^4$

$\frac{N}{N_0} = \frac{1}{16}$

8) A radioactive tracer used in a medical test has a half-life of 2.6 h. What proportion of this tracer will remain after 24 h? [0.17 %]

$\frac{N}{N_0} = ?$

$n = \frac{24\text{h}}{2.6\text{h}}$

$N = N_0\left(\frac{1}{2}\right)^n$

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{\frac{24}{2.6}}$

$\frac{N}{N_0} = 0.001664414837$

$\frac{N}{N_0} \approx 0.17\%$

9) An archaeologist finds a wooden arrow shaft with a proportion of carbon-14 that is about 25% of that in a living tree branch. Estimate the age of the arrow. [11 460 years]

$25\% = 0.25 = \frac{1}{4} = \frac{1}{2}\left(\frac{1}{2}\right)$

Two half lives!

Carbon-14 → 5730 years

$5730(2) = 11460$ years

11460 years old!

10) A sample of 1.0 g of tritium is produced. What will be the mass of tritium remaining after 24.6 years? [0.25 g]

$N_0 = 1.0\text{ g}$

$N = ?$

$n = \frac{24.6}{12.3} = 2$

$N = N_0\left(\frac{1}{2}\right)^n$

$N = 1.0\text{ g}\left(\frac{1}{2}\right)^2$

$N = 0.25\text{ g}$

11) The isotope $^{238}_{93}Np$ has a half-life of 2.0 d. If 4.0 g are produced on Monday, what will be the mass of the neptunium on Tuesday of the next week? [0.25 g]

$N_0 = 4.0\text{ g}$

$N = ?$

$n = \frac{8.0\text{ d}}{2.0\text{ d}} = 4$

$N = N_0\left(\frac{1}{2}\right)^n$

$N = 4.0\text{ g}\left(\frac{1}{2}\right)^4$

$N = 0.25\text{ g}$

12) Graph the data in this table. Then use your graph to estimate

a) the half-life of the material [5 h]
b) the activity of the sample at time $t = 0$ [3477 decays/min]

Time (h)	Activity (decays / min)
1	3027
2	2546
4	1800
6	1273
8	900
10	636